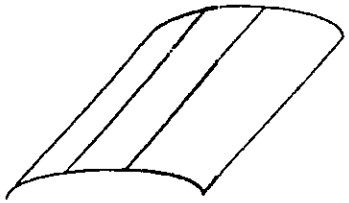
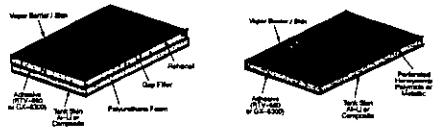
Lockheed Martin Demonstrations

Reusable Cryo Tank Systems
- Lined vs. Unlined Systems
- Alternate Geometry's (e.g., MultiLobe)
- Alternate Cryo Insul. Arch's
- Tagged Adhesives for Foam Bonding

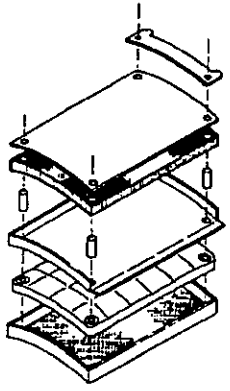
- **Metalized Polymeric Liner on IM7/977 Composite Characterization**
- **Four Tank Concepts**
- **24" Tanks for Cryocycling (4)**
- **5' x 5 ' Composite Curved Panel (2)**
  - **w/ Insul, Recert Sys.**
- **5' x 5 ' Al-Li Curved Panel (1)**
  - **w/ Insul, Recert Sys.**
- **3' x 3' Structural Joint (1)**
- **Three Insulation Concepts (Layered Foam, Honeycomb,Embeded Foam)**
  - **Al-Li and Composite Panels and 18" Tanks**
- **NDE/VHM Sensors for Recert. and Analytical Tools**





Thermal Protection Systems
- Alternate Metallic Designs
- Only C/C Effort

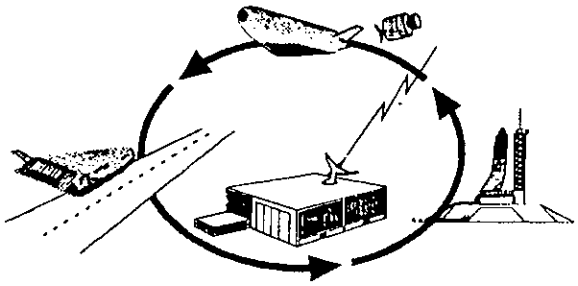
- **3 Metallic Concepts**
  - **Panels**
  - **Robustness & Arc Jet Testing**
  - **Post Damage Performance**
- **Ox Resistant C/C**
  - **Panels**
  - **Robustness & Arc Jet Testing**
  - **Post Damage Performance**
- **Attachment of Metallic TPS**
  - **Thermo -Vibro-Acoustic Testing**



Lockheed Martin Demonstrations

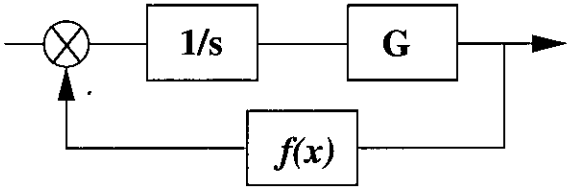
Operations
- Reduced Manpower
- Reduced Turnaround Time
- Increased Mission Success Rate

- **IVHM**
  - **Simulated RLV Mission w/Failures**
  - **Integrated Fault Tolerant Arch Lab in Avionics Facility in Denver**
  - **Network Multiple Subsystems:**
    - **Core: Avionics Lab (Denver)**
    - **Proto. Control Center (MAST)**
    - **STS MPS Test Rig (LSOC)**
    - **Cryo Tank VHM (MSFC)**
    - **RCS Controls Lab (JSC)**
    - **EMA Testbed (Denver)**



- **Propulsion Sys Diagnostics**
  - **Expert Systems, AI (A/C)**
  - **Integrate STS MPS Test Rig w/ On-board VHM & BIT**
  - **MAST Lab Simulations**
  - **Compare w/ STS Op's**

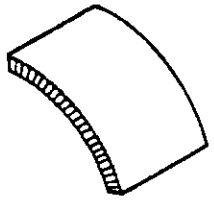
- **Adaptive GN&C (Ascent, Rendezvous, Land)**
  - **Develop Generic Arch.**
  - **Rapid Prototyping/Commercial Tool Approach**
  - **Simulation**



X-33 McDonnell Douglas / Boeing Demonstrations

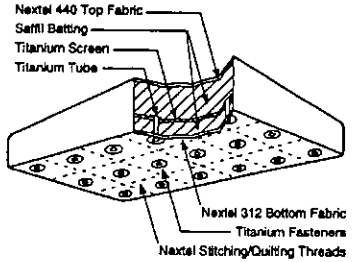
K3B Thermoplastic Cryo Tanks
- Vs. Thermoset
- Higher Temp.
- Lighter Weight

- **IM7/K3B (YF22 Wing)**
- **Sandwich Constuction**
- **Laminate & Honeycomb Coupons**
- **Thermal Conductivity**
- **Buckling & Cyclic Panels (w/Joints)**
- **Large 5' x 5' Curved Panel**
- **Test at Cryo and 400° F Temp's**



Mechanical Attachment of Flexible TPS
- Vs. Direct Bond
- Simplified Op's
- Higher Temp.

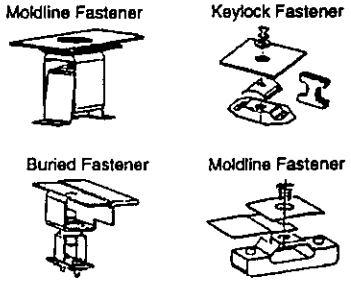
- **TABI and AFRSI**
- **Vibroacoustic and Arc Jet Tests**
- **12 Attachment Concepts**
- **15 - 12" Square Segments**



Candidate Concepts

Mechanical Attachment of Metallic & CMC TPS
- Alternate Methods (Only 1 in Current Efforts)
- Historical Problem Area

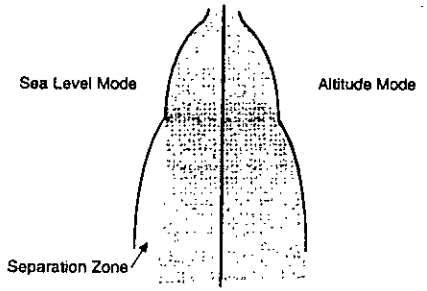
- **Metallic and CMC**
- **Vibroacoustic, Thermostructural Tests, & Arc Jet**
- **8 Attachment Concepts**
- **6" Square Segments**



X-33 McDonnell Douglas / Boeing Demonstrations

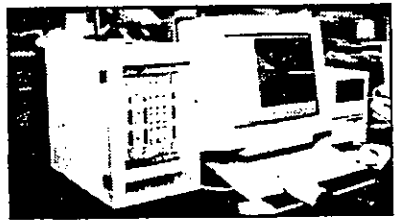
Dual Bell Nozzles
- More Optimum Performance Over Trajectory
- Reduced Startup Loads

- **Rocketdyne**
- **CFD Analyses: Contours and ε**
- **14 " Cold Flow Wind Tunnel Tests: Performance, Flow Transition, Slipstream, Control**



Autonomous Abort Technology
- Higher Mission Success Rate
- Reduced Manpower

- **Develop Adaptive Guidance Algorithims**
- **Develop Adaptive Control Algorithims**
- **Integrate into MIDS 6 DOF Simulator (Rapid Prototyping): Real Time Tests**
- **Integrate into MSFC MAST and C/O (extensive failure simulation)**
- **Compare MIDS to MAST Results**



Automated Mission Planning
- Reduced Manpower
- Reduced Turnarond Time

- **Develop Generic Vehicle Elements Database**
- **Develop Algorithims and Interfaces**
- **Develop & Integrate Code**
- **FOCC/DC-XA On-Site Simulation**

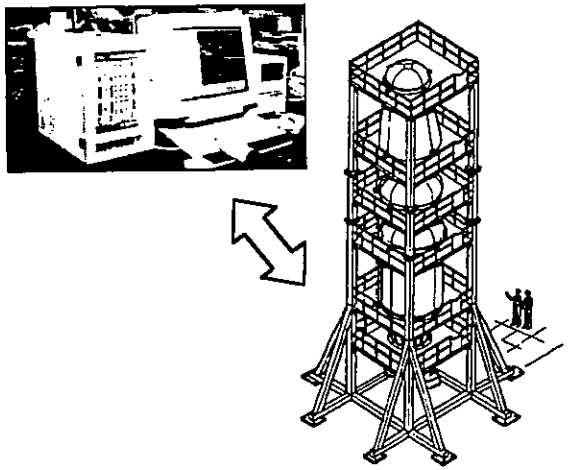
Automate:

-Mission Design
-Std Mission Mod's
-Hdwre, Payload, Environment Updates
-Optimization
-Post Flight Debrief

Rockwell Demonstrations

Informed Maintenance
- Reduced Manpower
- Reduced Turnaround Time
- Derived from A/C

- **Northrup Grumman/FedX**
- **On Board Fault Prediction, Detect, Ident, Reconfig (FPDIR)**
- **"Paperless" Systems w/ Portable Maintenance Aids**
- **Informed Mainenance Schedulers**
- **Tested on IPTD (Maintenance Database)**



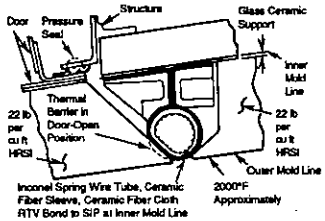
IPTD

Integrated Avionics/Software/VHM
- Reduced Development and Maintenance Cost thru Modularity and Automation

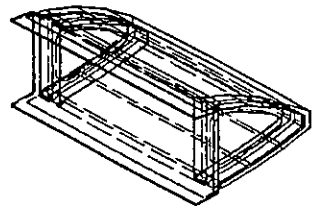
- **Develop Integrated Avionics Systems Architecture & Reusable Algorithims**
- **Rapid Prototyping (Commercial Tools)**
- **Integrate Software and Commercial Hdwre into LVIT, MAST Simulators**

Leading Edge and Thermal Seals
- Increased Robustness
- Reduced Maintenance Req'ts
- Reduced Weight

- **SIRCA Tile Covered Leading Edge**
- **2" Sq Coupons and 6" Sq Tiles**
- **Arc Jet & Robustness Testing (Rain, Hypervelocity, Tool Damage Effects)**



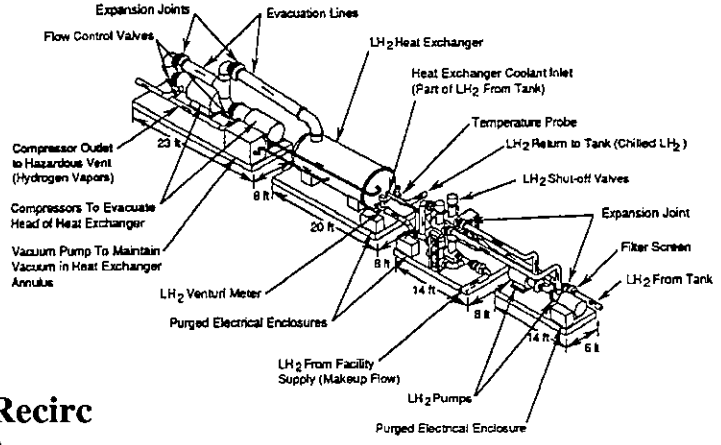
- **New Seal Designs / Materials (Nextel)**
  - **Orbiter / NASP Lessons Learned**
- **6" x 0.5" D Specimens**
- **Compression and Arc Jet Testing**



Rockwell Demonstrations

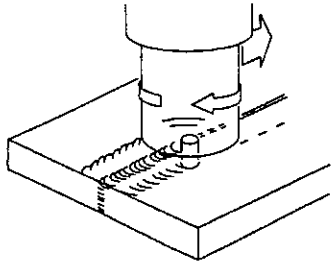
Propellant Densification
- Lighter Vehicle Dry Weight (15-20%) (Reduced Pressure and ρ)
- No On-Pad Venting Req'd

- **Subcool LOX 21.3°R**
  ($\Delta\rho$=3.2 lb/ft3, Δp_v=11.2psi)
  Subcool LH_2 8.5°R
  ($\Delta\rho$=0.29 lb/ft3, Δp_v=12.2psi)
- **LOX and LH2 Densifier /Recirc Units (Designed for IPTD)**
- **Operational Demo (Loading Time Savings ~ 3 hrs)**
- **Maintain Req'd ρ and press.**



Friction Stir Welding for Al-Li
- Higher Quality Welds
- Twice Allowable Gap Width
- Faster, Simplified Welding

- **In-House MSFC Support Task**

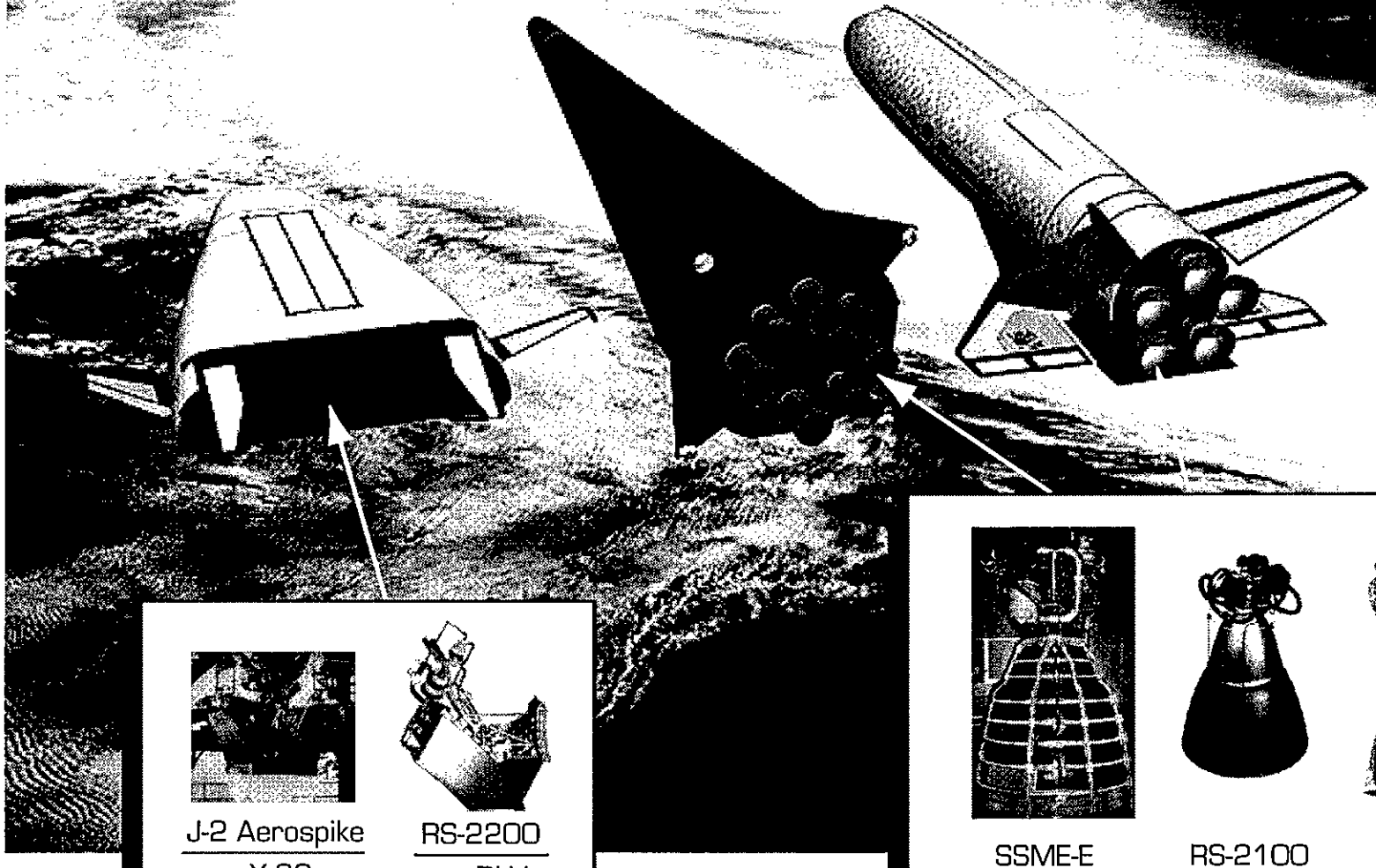


Advanced Propulsion

Jan Monk
May, 1995

Reusable Launch Vehicle Program

Propulsion System Concept Options



J-2 Aerospike

- X-33
- RLV

RS-2200

- RLV

SSME-E

- X-33
- RLV

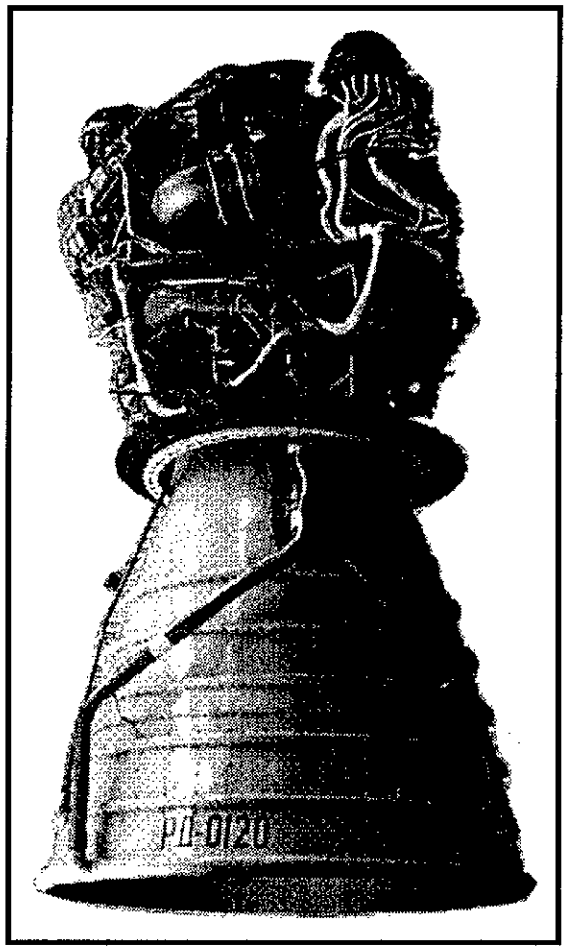
RS-2100

- RLV

RD-0120

- X-33
- RLV

Bipropellant Engine Options



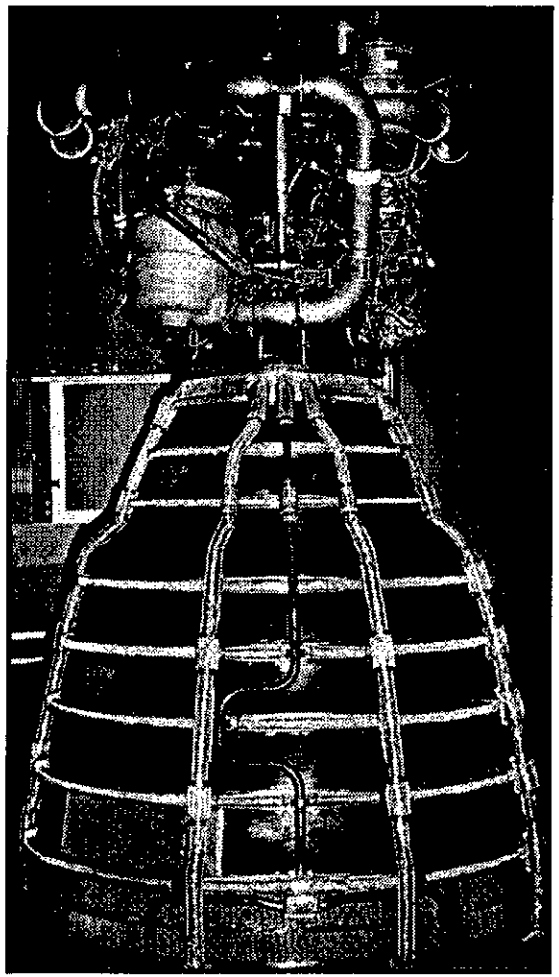
AEROJET/CADB Evolved RD-0120

Features
- Staged Combustion Cycle
- Fuel Rich Preburner
- RD-0120 Heritage

Supporting Technologies
- Life Extension
- Altitude Compensating Nozzle
- Composite Nozzle Extension
- Lightweight Nozzle
- Hardware-in-the-Loop Demonstration
- Operability Enhancements

Technology Base
- RD-0120
- STME

Bipropellant Engine Options



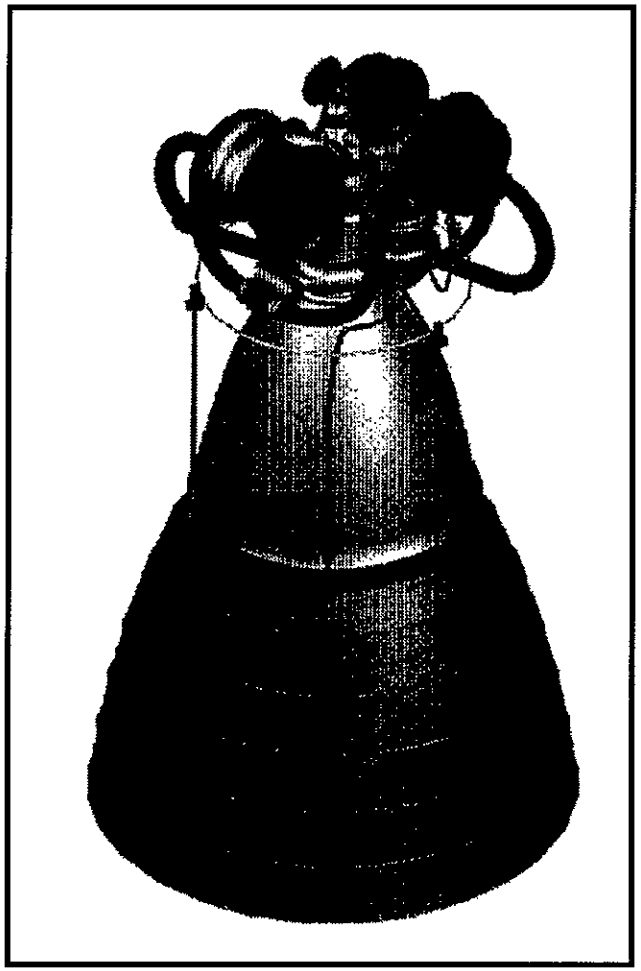
ROCKETDYNE - Evolved SSME

Features
- Staged Combustion Cycle
- Fuel Rich Preburner
- Dual Expansion Ratio Fixed Bell Nozzle

Supporting Technologies
- UMCC/AMCC
- Jet Boost Pumps
- Dual Bell Nozzle
- Composite Nozzle
- Sector Ball Valves/EMAs
- Operability/Producibility/Weight Improvement
- Operations Validation

Technology Base
- STME
- SSME

Bipropellant Engine Options



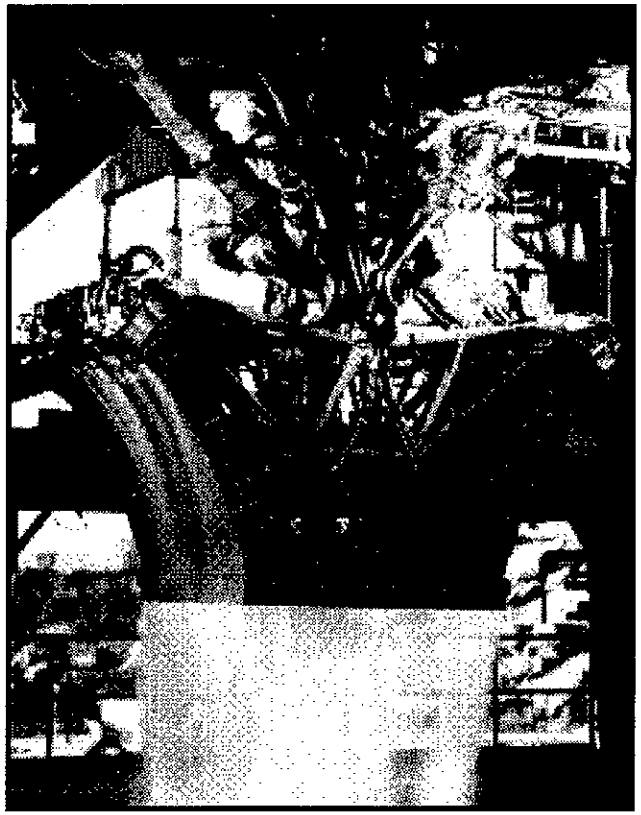
ROCKETDYNE - RS2100

Features
- Full Flow Staged Combustion Cycle
- Ox Rich Preburner
- Fuel Rich Preburner
- Dual Expansion Ratio Fixed Bell Nozzle

Supporting Technologies
- FSD Engine Definition
- Ox Rich Turbine Drive
- Gas-Gas Main Injector
- RRTT
- Jet Pumps
- Dual Bell Nozzle
- Robust Light weight Nozzle
- Composite Components
- EMA / Sector Ball Valves
- Health Management
- Catalyst Igniter
- Laser Ignition

Technology Base
- STME
- SSME

X-33 Bipropellant Engine Options



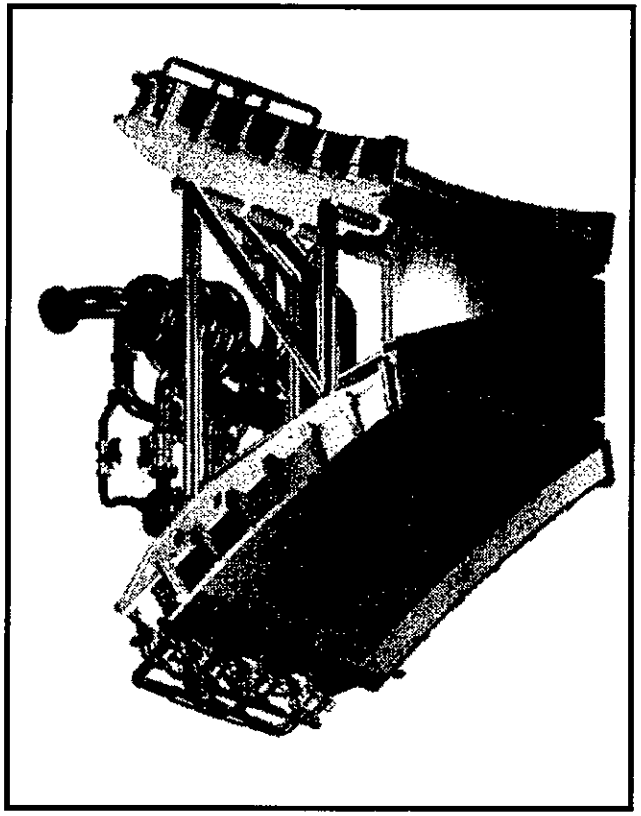
ROCKETDYNE - X-33 Aerospike

Features
- Gas Generator Cycle
- J-2S Turbomachinery
- Modular Combustion Chambers
- Conformal/Segmented Altitude Compensating Nozzle
- Variable Expansion Ratio

Supporting Technologies
- Single Thrust Cells
- Multicell Technology
- Sector Ball Valves/EMAs
- Aerospike Nozzle Development

Technology Base
- J-2/J-2S
- SSME
- 60's-70's Aerospike Programs

Bipropellant Engine Options



ROCKETDYNE - RS2200

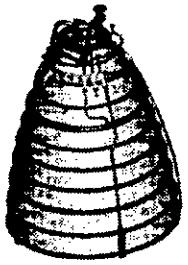
Features
- Gas Generator Cycle
- Modular Combustion Chambers
- Conformal/Segmented Altitude Compensating Nozzle
- Variable Expansion Ratio

Supporting Technologies
- Single Thrust Cell Technology
- Multicell Technology
- Aerospike Nozzle Development
- Composite Nozzle/Structure
- RRTT
- Jet Pumps
- EMA / Sector Ball Valves
- Health Management
- Laser ignition

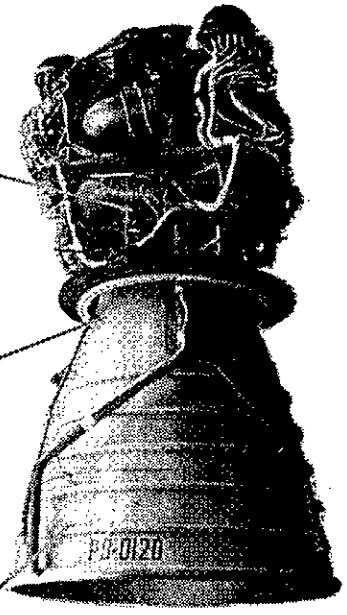
Technology Base
- STME
- SSME
- 60's-70's Aerospike

Aerojet/CADB Evolved RD-0120 Supporting Technologies

Altitude Compensating Nozzle



Lightweight Nozzle



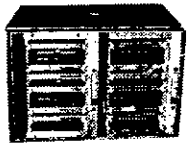
RD-0120

Composite Nozzle Extension

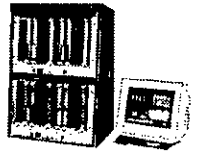
Additional RD-0102 Technologies

Operability Enhancements

Breadboard Controller

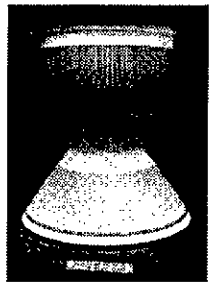


Informed Maintenance Diagnostics & Display

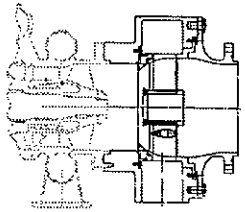


Electromechanical Actuators

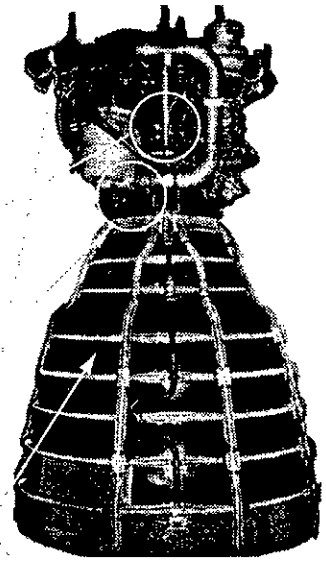
SSME-E/RS-2100 Supporting Technologies



UMCC/AMCC



Jet Boost Pumps

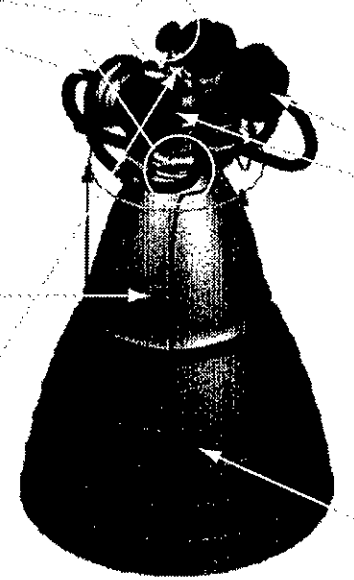


SSME-E

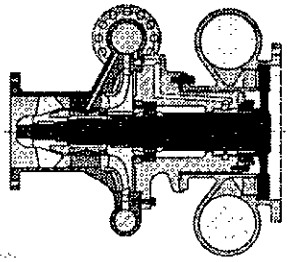
Additional RS-2100 Technologies:

- *Ox-Rich Turbine Drive*
- *Gas-Gas Main Injector*
- *Composite Components*
- *Health Management*
- *Catalyst Ignitor*
- *Laser Ignition*

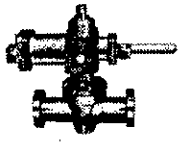
Dual Bell Nozzle



RS-2100



RRTT



Sector Ball Valves/EMA's

Composite Nozzle Skirt